Title: Drilling down: fact vs fiction in the great fracking debate
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Thousands of feet beneath rural Pennsylvania and its freshwater aquifers, dogleg drilling and hydraulic pressure combine to fracture the Marcellus Shale and ^ siphon its vast natural gas 9 reserves. But the techniques m raise environmental concerns.

MODEL NOT TO SCALE

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Less than a decade ago, industry analysts and government officials fretted that the United States was in danger of running out of gas. No more. Over the past several years, vast caches of natural gas trapped in deeply buried rock have been made accessible by advances in two key technologies: horizontal drilling, which allows vertical wells to turn and snake more than a mile sideways through the earth, and hydraulic fracturing, or fracking. Developed more than 60 years ago, fracking involves pumping millions of gallons of chemically treated water into deep shale formations at pressures of 9000 pounds per square inch or more. This fluid cracks the shale or widens existing cracks, freeing hydrocarbons to flow toward the well.

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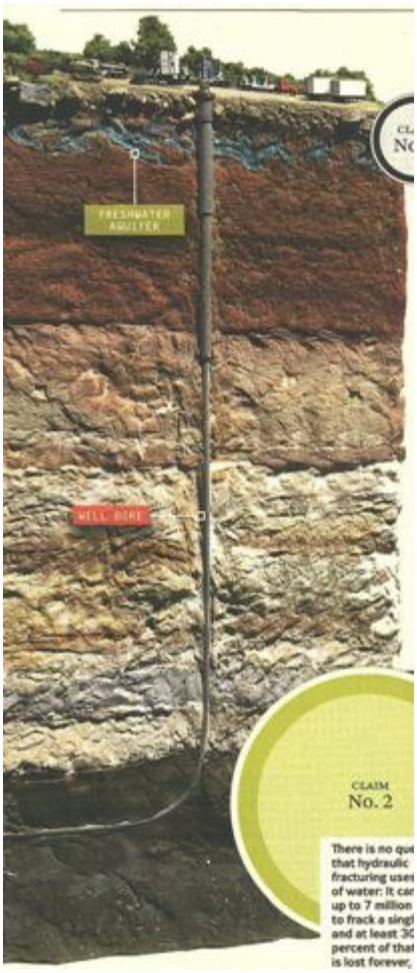
These advances have led to an eightfold increase in shale gas production over the past decade. According to the Energy Information Administration, shale gas will account for nearly half of the natural gas produced in the U.S. by 2035. But the bonanza is not without controversy, and nowhere, perhaps, has the dispute over fracking grown more heated than in the vicinity of the Marcellus Shale. According to Terry Engelder, a professor of geo-sciences at Penn State, the vast formation sprawling primarily beneath West Virginia, Pennsylvania and New York could produce an estimated 493 trillion cubic feet of gas over its 50- to 100-year life span. That's nowhere close to Saudi Arabia's total energy reserves, but it is enough to power every natural gas-burning device in the country for more than 20 years. The debate over the Marcellus Shale will shape national energy policy--including how fully, and at what cost, we exploit this vast resource.



There is no question that hydraulic fracturing uses a lot of water: It can take up to 7 million gallons to frack a single well, and at least 30 percent of that water is lost forever, after being trapped deep in the shale. And while there is some evidence that fracking has contributed to the depletion of water supplies in drought stricken Texas, a study by Carnegie Mellon University indicates the Marcellus region has plenty of water and, in most cases, an adequate system to regulate its usage. The amount of water required to drill all 2916 of the Marcellus wells permitted in Pennsylvania in the first 11 months of 2010 would equal the amount of drinking water used by just one city, Pittsburgh, during the same period, says environmental engineering professor Jeanne VanBriesen, the study's lead author. Plus, she notes, water withdrawals of this new industry are taking the place of water once used by industries, like steel manufacturing, that the state has lost. Hydrogeologist David Yoxtheimer of Penn State's Marcellus Center for Outreach and Research gives the withdrawals more context: Of the 9.5 billion gallons of water used daily in Pennsylvania, natural gas development consumes 1.9 million gallons a day (mgd); livestock use 62 mgd; mining, 96 mgd; and industry, 770 mgd.

Burning natural gas is cleaner than oil or gasoline, and it emits half as much carbon dioxide, less than one-third the nitrogen oxides, and 1 percent as much sulfur oxides as coal combustion. But not all shale gas makes it to the fuel tank or power plant. The methane that escapes during the drilling process, and later as the fuel is shipped via pipelines, is a significant greenhouse gas. At least one scientist, Robert Howarth at Cornell University, has calculated that methane losses could be as high as 8 percent. Industry officials concede that they could be losing anywhere between 1 and 3 percent. Some of those leaks can be prevented by aggressively sealing condensers, pipelines and wellheads. But there's another upstream factor to consider: Drilling is an energy-intensive business. It relies on diesel engines and generators running around the clock to power rigs, and heavy trucks making hundreds of trips to drill sites before a well is completed. Those in the industry say there's a solution at hand to lower emissions--using natural gas itself to power the process. So far, however, few companies have done that.

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The senator is incorrect. In the past two years alone, a series of surface spills, including two blowouts at wells operated by Chesapeake Energy and EOG Resources and a spill of 8000 gallons of tracking fluid at a site in Dimock, Pa., have contaminated groundwater in the Marcellus Shale region. But the idea stressed by fracking critics that deep-injected fluids will migrate into groundwater is mostly false. Basic geology prevents such contamination from starting below ground. A fracture caused by the drilling process would have to extend through the several thousand feet of rock that separate deep shale gas deposits from freshwater aquifers. According to geologist Gary Lash of the State University of New York at Fredonia, the intervening layers of rock have distinct mechanical properties that would prevent the fissures from expanding a mile or more toward the surface. It would be like stacking a dozen bricks on top of each other, he says, and expecting a crack in the bottom brick to extend all the way to the top one. What's more, the fracking fluid itself, thickened with additives, is too dense to ascend upward through such a channel. EPA officials are closely watching one place for evidence otherwise: tiny Pavillion, Wyo., a remote town of 160 where high levels of chemicals linked to fracking have been found in groundwater supplies. Pavillion's aquifer sits several hundred feet above the gas cache, far closer than aquifers atop other gas fields. If the investigation documents the first case of fracking fluid seeping into groundwater directly from gas wells, drillers may be forced to abandon shallow deposits--which wouldn't affect Marcellus wells.

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SHALE GAS NATION

The Energy Information Administration estimates the U.S. has 2552 trillion cubic feet of potential natural gas resources.

Much of the political opposition to fracking has focused on the Catskill region, headwaters of the Delaware River and the source of most of New York City's drinking water. But the expected boom never happened--there's not enough gas in the watershed to make drilling worthwhile. "No one has to get excited about contaminated New York City drinking water," Penn State's Engelder told the Times Herald-Record of Middle-town, N.Y., in April. The shale is so close to the surface that it's not concentrated in large enough quantities to make recovering it economically feasible. But just to the west, natural gas development is dramatically changing the landscape. Drilling rigs are running around the clock in western Pennsylvania. Though buoyed by the economic windfall, residents fear that regulators can't keep up with the pace of development. "It's going to be hard to freeze-frame and say, 'Let's slow down,'" Sen. Robert P. Casey Jr., D-Pa., said last fall. "That makes it more difficult for folks like us, who say we want to create the. jobs and opportunity in the new industry, but we don't want to do it at the expense of water quality and quality of life."

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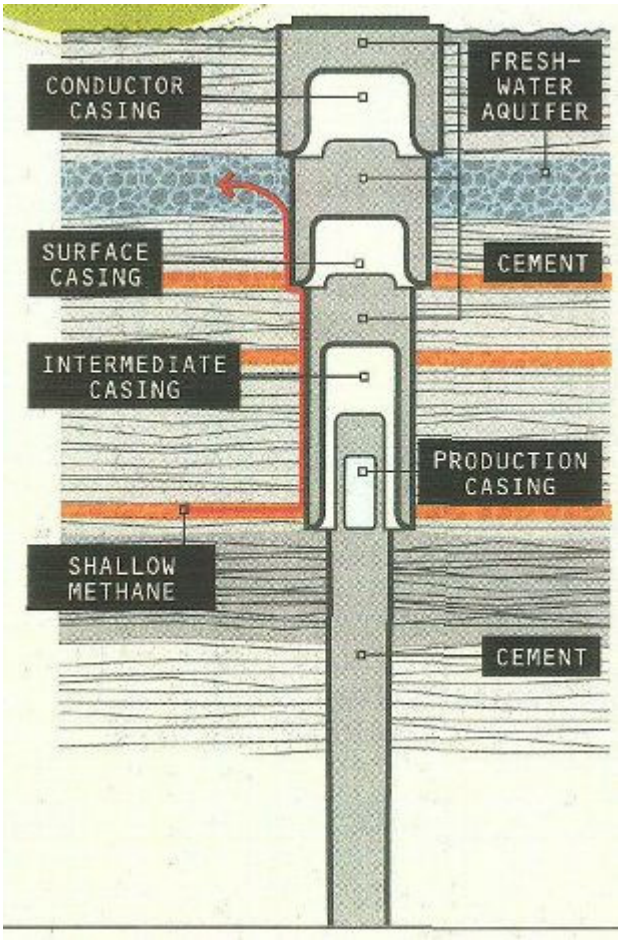
That may be true. Plus, there's another incentive: Vehicles powered by liquefied natural gas, propane or compressed natural gas run cleaner than cars with either gasoline or diesel in the tank. According to the Department of Energy, if the transportation sector switched to natural gas, it would cut the nation's carbon-monoxide emissions by at least 90 percent, carbon-dioxide emissions by 25 and nitrogen-oxide emissions by up to 60. But it's not realistic: Nationwide, there are only about 3500 service stations (out of 120,000) that offer natural gas-based automotive fuel, and it would cost billions of dollars and take years to develop sufficient infrastructure to make that fuel competitive with gasoline or diesel. And only Honda makes a car that can run on natural gas. That doesn't mean natural gas has no role in meeting the nation's short-term transportation needs. In fact, buses in several cities now rely on it, getting around the lack of widespread refueling opportunities by returning to a central terminal for a fill-up. The same could be done for local truck fleets. But perhaps the biggest contribution natural gas could make to America's transportation picture would be more indirect--as a fuel for electric-generation plants that will power the increasingly popular plug-in hybrid vehicles.

It's an iconic image, captured in the 2010 Academy Award-nominated documentary GasLand. A Colorado man holds a flame to his kitchen faucet and turns on the water. The pipes rattle and hiss, and suddenly a ball of fire erupts. It appears a damning indictment of the gas drilling nearby. But Colorado officials determined the gas wells weren't to blame; instead, the homeowner's own water well had been drilled into a naturally occurring pocket of methane. Nonetheless, up to 50 layers of natural gas can occur between the surface and deep shale formations, and methane from these shallow deposits has intruded on groundwater near fracking sites. In May, Pennsylvania officials fined Chesapeake Energy $1 million for contaminating the water supplies of 16 families in Bradford County. Because the company had not properly cemented its boreholes, gas migrated up along the outside of the well, between the rock and steel casing, into aquifers. The problem can be corrected by using stronger cement and processing casings to create a better bond, ensuring an impermeable seal.



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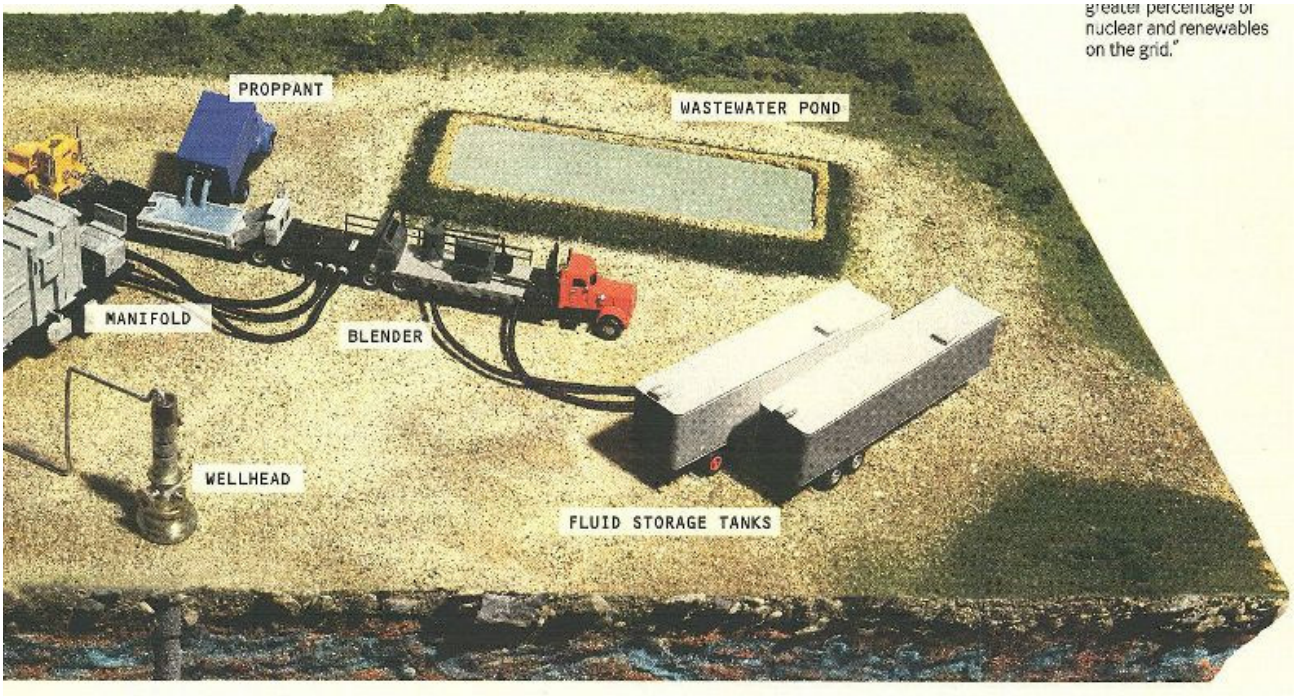
Shale has a radioactive signature--from uranium isotopes such as radium-226 and radium-228--that geologists and drillers often measure to chart the vast underground formations. The higher the radiation levels, the greater the likelihood those deposits will yield significant amounts of gas. But that does not necessarily mean the radioactivity poses a public health hazard; after all, some homes in Pennsylvania and New York have been built directly on Marcellus shale. Tests conducted earlier this year in Pennsylvania waterways that had received treated water--both produced water (the fracking fluid that returns to the surface) and brine (naturally occurring water that contains radioactive elements, as well as other toxins and heavy metals from the shale)--found no evidence of elevated radiation levels. Conrad Dan Volz, former scientific director of the Center for Healthy Environments and Communities at the University of Pittsburgh, is a vocal critic of the speed with which the Marcellus is being developed--but even he says that radioactivity is probably one of the least pressing issues. "If I were to bet on this, I'd bet that it's not going to be a problem," he says.

[ILLUSTRATION OMITTED]

Under mounting pressure, companies such as Schlumberger and Range Resources have posted the chemical compounds used in some of their wells, and in June, Texas became the first state to pass a law requiring full public disclosure. This greater transparency has revealed some oddly benign ingredients, such as instant coffee and walnut shells--but also some known and suspected carcinogens, including benzene and methanol. Even if these chemicals can be found under kitchen sinks, as industry points out, they're poured down wells in much greater volumes: about 5000 gallons of additives for every 1 million gallons of water and sand. A more pressing question is what to do with this fluid once it rises back to the surface. In Texas's Barnett Shale, wastewater can be reinjected into impermeable rock 1.5 miles below ground. This isn't feasible in the Marcellus Shale region; the underlying rocks are not porous enough. Currently, a handful of facilities in Pennsylvania are approved to treat the wastewater. More plants, purpose-built for the task, are planned. In the meantime, most companies now recycle this water to drill their next well.



There's little question that the United States, with 110 years'worth of natural gas (at the 2009 rate of consumption), is destined to play a major role in the fuel's development. But even its most ardent supporters, men like T. Boone Pickens, concede that it should be a bridge fuel between more polluting fossil fuels and cleaner, renewable energy. In the meantime, the U.S. should continue to invest in solar and wind, conserve power and implement energy-efficient technology. Whether we can effectively manage our natural gas resource while developing next-gen

sources remains to be seen. Margie Tatro, director of fuel and water systems at Sandia National Laboratories, says, "I think natural gas is a transitioning fuel for the electricity sector until we can get a greater percentage of nuclear and renewables on the grid."

RELATED ARTICLE: SURFACE OPERATIONS

At the blender, fracking chemicals and proppant--particulates like sand that hold open fractures in the shale--are added to pure or recycled water from fluid storage tanks. This slurry is transferred through the manifold to pumpers, which boost the pressure. The manifold then directs it into a high-pressure line leading to the well. When the liquid returns to the surface after fracking, it's stored in a lined wastewater pond for treatment or recycling. Multiply each truck in this model by 10 and the storage tanks by 50 and you begin to approach the scale of a natural gas operation.

"WE ARE THE SAUDI ARABIA OF NATURAL GAS."

SEN. JOHN KERRY, D-MASS., MAY 2010

"HYDRAULIC FRACTURING SQUANDERS OUR PRECIOUS WATER RESOURCES."

Green Party of Pennsylvania, April 2011

"NATURAL-GAS IS CLEANER, CHEAPER, DOMESTIC, AND IT'S VIABLE NOW."

OILMAN TURNED NATURAL-GAS CHEERLEADER T. BOONE PICKENS, SEPTEMBER 2009

"[THERE'S] NEVER BEEN ONE CASE-DOCUMENTED CASE-OF GROUNDWATER CONTAMINATION IN THE HISTORY OF THE THOUSANDS AND THOUSANDS OF HYDRAULIC FRACTURING [WELLS]."

SEN. JAMES INHOFE, R-OKLA., APRIL 2011

"THE GAS ERA IS COMING, AND THE LANDSCAPE NORTH AND WEST OF [NEW YORK CITY] WILL INEVITABLY BE TRANSFORMED AS A RESULT. WHEN THE VALVES START OPENING NEXT YEAR, A LOT OF POOR FARM FOLK MAY BECOME TEXAS RICH. AND A LOT OF OTHER PEOPLE--ESPECIALLY THE ECOSENSITIVE NEW YORK CITY CROWD THAT HAS SETTLED AMONG THEM--WILL BE APOPLECTIC AS THEIR PRISTINE WEEKEND SANCTUARY IS CONVERTED INTO AN INDUSTRIAL ZONE, CRISSCROSSED WITH DRILL PADS, PIPELINES, AND ACCESS ROADS."

New York magazine, Sept 21,2008

"NATURAL GAS IS AFFORDABLE, ABUNDANT AND AMERICAN. IT COSTS ONE-THIRD LESS TO FILL UP WITH NATURAL GAS THAN TRADITIONAL GASOLINE."

REP. JOHN LARSON, D-CONN., CO-SPONSOR OF H.R. 1380, A MEASURE THAT WOULD PROVIDE TAX INCENTIVES FOR THE DEVELOPMENT AND PURCHASE OF NATURAL GAS VEHICLES, MARCH 2011

"DO NOT DRINK THIS WATER"

HANDWRITTEN SIGN IN THE DOCUMENTARY GASLAND, 2010

"AS NEW YORK GEARS UP FOR A MASSIVE EXPANSION OF GAS DRILLING IN THE MARCELLUS SHALE, STATE OFFICIALS HAVE MADE A POTENTIALLY TROUBLING DISCOVERY ABOUT THE WASTEWATER CREATED BY THE PROCESS: IT'S RADIOACTIVE."

ProPublica, November 2009

"CLAIMING THAT THE INFORMATION IS PROPRIETARY, DRILLING COMPANIES HAVE STILL NOT COME OUT AND FULLY DISCLOSED WHAT FRACKING FLUID IS MADE OF."

Vanity Fair, June 2010

"THE INCREASING ABUNDANCE OF CHEAP NATURAL GAS, COUPLED WITH RISING DEMAND FOR THE FUEL FROM CHINA AND THE FALL-OUT THE FUKUSHIMA NUCLEAR DISASTER IN JAPAN, MAY HAVE SET THE STAGE FOR A 'GOLDEN AGE OF GAS.'"

WALL STREET JOURNAL SUMMARIZING AN INTERNATIONAL ENERGY AGENCY REPORT, JUNE 6, 2011

MODELS AND MAP BY MEGAN CAPONETTO

PHOTOGRAPH BY TOM SCHIERLITZ

McGraw, Seamus